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For: PHOTONIC CRYSTAL INTERFEROMETRIC FIBER OPTICAL  
GYROSCOPE SYSTEM

1           1.     A photonic crystal interferometric optical gyroscope system comprising:  
2                     a light source for providing a primary beam of light;  
3                     a photonic crystal sensing coil having a rotational axis; and  
4                     a beam controlling device configured to split said primary beam into first  
5     and second counter-propagating beams in said photonic crystal sensing coil and  
6     configured to direct return of said counter-propagating beams wherein the power of said  
7     returning counter-propagating beams represents the phase shift between said counter-  
8     propagating beams and is indicative of the rate of rotation of said coil about said  
9     rotational axis.

1           2.     The system of claim 1 in which said photonic crystal sensing coil is  
2     formed by winding a photonic crystal fiber having a gas-solid structure that confines said  
3     light by total internal reflection.

1           3.     The system of claim 1 in which said photonic crystal sensing coil is  
2     formed by winding a band gap fiber which confines said light by employing an optical  
3     band gap.

1           4.     The system of claim 2 in which said photonic crystal fiber is configured to  
2     maintain the polarization of said first and second counter-propagating beams.

1           5.     The system of claim 2 in which said photonic crystal fiber is configured to  
2     propagate only one state of polarization of said first and second counter-propagating  
3     beams.

1           6.     The system of claim 2 in which said photonic crystal fiber is configured to  
2     propagate a single mode of light.

1           7.     The system of claim 3 in which said band gap fiber is configured to  
2     maintain the polarization of said light.

1           8.     The system of claim 3 in which said band gap fiber is configured to  
2     propagate only one state of polarization of said light.

1           9.     The system of claim 3 in which said band gap fiber is configured to  
2     propagate a single mode of light.

1           10.    The system of claim 2 in which said photonic crystal sensing coil includes  
2     15,000 turns of said photonic crystal fiber.

1           11.    The system of claim 2 in which said photonic crystal sensing coil includes  
2     35,000 turns of said photonic crystal fiber.

1           12.    The system of claim 3 in which said photonic crystal sensing coil includes

2        15,000 turns of said band gap fiber.

1            13.     The system of claim 3 in which said photonic crystal sensing coil includes  
2        35,000 turns of said band gap fiber.

1            14.     The system of claim 2 in which said photonic crystal fiber includes a solid  
2        core region surrounded by solid clad having a plurality of hollow channels configured to  
3        provide an index of refraction difference between said solid core region and said clad that  
4        confines light in said core by totally reflecting light on said clad and propagates a single  
5        mode of light.

1            15.     The system of claim 14 further including a jacket surrounding said clad.

1            16.     The system of claim 14 in which said photonic crystal fiber has an outer  
2        diameter in the range of about 20 to 250 microns.

1            17.     The system of claim 14 in which said photonic crystal fiber has an outer  
2        diameter in the range of about 70 microns.

1            18.     The system of claim 14 in which said photonic crystal fiber has an outer  
2        diameter of about 40 microns.

1            19.     The system of claim 14 in which said solid core and said clad are made of

2 silica, and/or plastic, and/or a dielectric material.

1 20. The system of claim 3 in which said band gap fiber includes a hollow core  
2 region surrounded by a solid clad including a plurality of hollow channels configured to  
3 define a band gap which confines the majority of light in said hollow core region and  
4 propagates a single mode of light.

1 21. The system of claim 20 further including a jacket surrounding said clad.

1 22. The system of claim 20 in which said band gap fiber has an outer diameter  
2 in the range of about 20 to 250 microns.

1 23. The system of claim 20 in which said band gap fiber has an outer diameter  
2 of about 70 microns.

1 24. The system of claim 20 in which said band gap fiber has an outer diameter  
2 of about 40 microns.

1 25. The system of claim 20 in which said clad is made of silica, and/or plastic,  
2 and/or a dielectric material.

1 26. The system of claim 3 in which said band gap fiber includes a hollow core  
2 region surrounded by solid clad having a plurality of alternating layers of solid dielectric

3 material, said alternating layers of dielectric material configured to create a band gap  
4 effect that confines the majority of light in said hollow core region and propagates a  
5 single mode of light.

1 27. The system of claim 26 in which said band gap fiber further includes a  
2 jacket surrounding said clad.

1 28. The system of claim 26 in which said band gap fiber has an outer diameter  
2 in the range of about 20 to 250 microns.

1 29. The system of claim 26 in which said band gap fiber has an outer diameter  
2 of about 70 microns.

1 30. The system of claim 26 in which said band gap fiber has an outer diameter  
2 of about 40 microns.

1 31. The system of claim 26 in which said alternating layers of solid dielectric  
2 material includes silica and/or plastic.

1 32. The system of claim 26 in which said alternating layers of solid dielectric  
2 material includes a material chosen from the group consisting of: silica, doped silica,  
3 fluoride glasses, chalcogenide glasses and thermoplastic polymers.

1           33.     The system of claim 4 in which said photonic crystal fiber includes an  
2 asymmetric solid core region surrounded by a solid clad having a plurality of  
3 asymmetrically spaced hollow channels about said solid core region to provide an index  
4 of refraction difference between said core region and said clad that confines said light by  
5 totally reflecting light on said hollow channels of said clad and maintains said  
6 polarization of said light.

1           34.     The system of claim 7 in which said band gap fiber includes an  
2 asymmetric hollow region surrounded by a solid clad having a plurality of asymmetrically  
3 spaced hollow channels configured to define a band gap effect that confines the majority  
4 of light in said hollow core and maintains said polarization of said light.

1           35.     The system of claim 7 in which said band gap fiber includes an  
2 asymmetric hollow core region surrounded by a plurality of alternating asymmetric layers  
3 of solid dielectric material configured to define a band gap effect that confines the  
4 majority of light in said core region and maintains said polarization of said light.

1           36.     The system of claim 5 in which said photonic crystal fiber includes an  
2 asymmetric solid core region surrounded by a solid clad having a plurality of  
3 asymmetrically spaced hollow channels about said solid core region configured to provide  
4 an index of refraction difference between said core region and said clad that confines light  
5 by totally reflecting light on said hollow channels of said clad and propagates said one  
6 state of polarized light.

1           37.     The system of claim 8 in which said band gap fiber includes an  
2     asymmetric hollow region surrounded by a solid clad having a plurality of asymmetrically  
3     spaced hollow channels configured to define a band gap that confines the majority of light  
4     in said hollow core and propagates said one state of polarized light.

1           38.     The system of claim 8 in which said band gap fiber includes an  
2     asymmetric hollow core region surrounded by clad including a plurality of alternating  
3     asymmetric layers of solid dielectric material configured to define a band gap that  
4     confines the majority of light in said core region and propagates one state of polarized  
5     light.

1           39.     The system of claim 1 in which photonic crystal sensing coil has an outer  
2     diameter, an inner diameter, and a height, said outer diameter in the range of about 0.5  
3     inches to 9 inches, said inner diameter in the range of about 0.5 to 8 inches, and said  
4     height in the range of about 0.25 to 4 inches.

1           40.     The system of claim 39 in which photonic crystal sensing coil has an outer  
2     diameter of about 2.0 inches, an inner diameter of about 1.5 inches, and a height of about  
3     1.0 inch.

1           41.     The system of claim 39 in which photonic crystal sensing coil has an outer  
2     diameter of about 0.75 inches, an inner diameter of about 0.5 inches, and a height of  
3     about 0.75 inches.

1           42.     The system of claim 1 further including an optical wave guide configured  
2     to interconnect said light source and said beam controlling device and/or said beam  
3     controlling device and photonic crystal sensing coil.

1           43.     The system of claim 42 in which said optical wave guide is chosen from  
2     the group consisting of: a solid structure wave guide that confines said light by total  
3     internal reflection, a photonic crystal wave guide having a gas-solid structure that  
4     confines said light by total internal reflection, and a band gap wave guide that confines  
5     said light by employing an optical band gap.

1           44.     The system of claim 43 wherein said solid structure wave guide is  
2     configured as an optical fiber, said photonic crystal wave guide is configured as photonic  
3     crystal fiber, and said band gap wave guide is configured as a band gap optical fiber.

1           45.     The system of claim 44 in which said optical fiber, said photonic crystal  
2     fiber, and said band gap fiber are configured to maintain the polarization of said light.

1           46.     The system of claim 44 in which said optical fiber, said photonic crystal  
2     fiber, and said band gap fiber are configured to propagate only one state of polarization of  
3     said light.

1           47.     The system of claim 44 in which said optical fiber, said photonic crystal  
2     fiber, and said band gap fiber are configured to propagate a single mode of light.



1           48.    The system of claim 1 in which said beam controlling device includes first  
2           and second optical splitters and a least one phase modulator.

1           49.    The system of claim 48 in which said first optical splitter is a reciprocal  
2           splitter.

1           50.    The system of claim 48 in which said first optical splitter is a non-  
2           reciprocal splitter.

1           51.    The system of claim 48 in which said first optical splitter is configured to  
2           direct light from said light source to a coil splitter and direct the return of said first and  
3           second counter-propagating beams from said sensing coil to a light detector.

1           52.    The system of claim 51 in which said first optical splitter is configured as  
2           a broad-band splitter to transmit light with a spectral width up to about 1500 nm.

1           53.    The system of claim 51 in which said second optical splitter is a reciprocal  
2           splitter.

1           54.    The system of claim 48 in which said second optical splitter is configured  
2           to divide said light from said light source into two equal said first and second counter-  
3           propagating beams.

1           55.     The system of claim 48 in which said at least one phase modulator is  
2     configured to add a time dependent phase shift to said first and second counter-  
3     propagating beams to produce a phase shift between said first and second counter-  
4     propagating beams such that said first and second counter-propagating beams  
5     constructively interfere to modify said power thereby improving the precision of said  
6     system.

1           56.     The system of claim 1 further including a photo detector configured to  
2     convert said power to an electrical signal.

1           57.     The system of claim 56 in which said photo detector is chosen from the  
2     group consisting of: a PIN photo detector, an avalanche photo detector, a photo multiplier  
3     tube, a bolometer, a photo resistive detector, and a photo conductive detector.

1           58.     The system of claim 1 in which said light source provides said primary  
2     beam of light having a wavelength in the range of about 100 nm to 15,000 nm.

1           59.     The system of claim 1 in which said light source provides said primary  
2     beam of light having a wavelength of about 1200 nm.

1           60.     The system of claim 59 in which said light source is chosen from the  
2     group consisting of: an amplified spontaneous emission light source, a stimulated  
3     emission light source, a thermally excited light source, a fluorescent light source, an

4        electro-luminescence light source, a chemical luminescence light source, and a  
5        phosphorescence light source.

1            61.     The system of claim 60 in which said amplified spontaneous emission  
2        light source includes a semiconductor material.

1            62.     The system of claim 60 in which said amplified spontaneous emission  
2        light source includes a gas filled fiber, and/or a rare earth doped fiber.

1            63.     The system of claim 62 in which said gas is chosen from the group  
2        consisting of: argon, helium, neon, carbon monoxide and carbon dioxide.

1            64.     The system of claim 60 in which said amplified spontaneous emission  
2        light source includes a liquid filled fiber.

1            65.     The system of claim 64 in which said liquid includes an organic dopant.

1            66.     The system of claim 60 in which said stimulated emission light source  
2        includes a laser.

1            67.     The system of claim 60 in which said stimulated emission light source is  
2        chosen from the group consisting of: a helium-neon doped fiber with a cavity, an argon  
3        doped fiber with a cavity, a carbon dioxide doped fiber with a cavity, and a

4 semiconductor material with a cavity.

1 68. The system of claim 60 in which said thermally excited light source  
2 includes an incandescent light bulb.

1 69. The system of claim 60 in which said fluorescent light source includes a  
2 fluorescent light bulb.

1 70. The system of claim 1 in which said light source is a broad-band light  
2 source which emits light with a spectral width up to about 1500 nm.

1 71. The system of claim 1 in which said light source is a broad-band light  
2 source which emits light with a spectral width of about 1200 nm.

1 72. The system of claim 1 in which said photonic crystal sensing coil has an  
2 ARW of about 0.001 degree/ $\sqrt{\text{hr}}$ .

1 73. The system of claim 1 in which said photonic crystal sensing coil has an  
2 ARW of about 0.00005 degree/ $\sqrt{\text{hr}}$ .

1           74.    A photonic crystal interferometric optical gyroscope system comprising:  
2                   a broad-band light source for providing a primary beam of light with  
3   increased spectral width;  
4                   a photonic crystal sensing coil having a rotational axis; and  
5                   a beam controlling device configured to split said primary beam into first  
6   and second counter-propagating beams in said photonic crystal sensing coil and  
7   configured to direct return of said counter-propagating beams; wherein the power of said  
8   returning counter-propagating beams represents the phase shift between said counter-  
9   propagating beams and is indicative of the rate of rotation of said coil about said  
10   rotational axis.

1           75.    The system of claim 74 in which said light source is a tungsten-halogen  
2   light source.

1           76.    The system of claim 74 in which said primary beam of light has a spectral  
2   width up to about 1500 nm.

1           77.    The system of claim 74 in which said photonic crystal sensing coil is  
2   formed by winding a photonic crystal fiber having a gas-solid structure that confines said  
3   light by total internal reflection.

1           78.    The system of claim 74 in which said photonic crystal sensing coil is  
2   formed by winding a band gap fiber which confines said light by employing an optical

3 band gap.

1 79. The system of claim 77 in which said photonic crystal fiber is configured  
2 to maintain the polarization of said first and second counter-propagating beams.

1 80. The system of claim 77 in which said photonic crystal fiber is configured  
2 to propagate only one state of polarization of said first and second counter-propagating  
3 beams.

1 81. The system of claim 77 in which said photonic crystal fiber is configured  
2 to propagate a single mode of light.

1 82. The system of claim 78 in which said band gap fiber is configured to  
2 maintain the polarization of said light.

1 83. The system of claim 78 in which said band gap fiber is configured to  
2 propagate one state of polarization of said light.

1 84. The system of claim 78 in which said band gap fiber is configured to  
2 propagate a single mode of light.